Power Lines and Land Value

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Abstract. This study attempts to detect whether power lines, power line towers, or both have an impact on the selling price of proximate residential land and to measure the magnitude of these impacts if they exist. Secondly, it attempts to determine whether any impact which is found to exist is diminished through time possibly as the growth of trees obscures the view of towers and lines, as attitudes change, or as uncertainty about the effects diminishes. Finally, the extent to which the impact extends beyond lots with an easement is considered. Throughout, the focus is on the value of land even though the use of developed property sales would ordinarily preclude such a focus. The approach is that of a hedonic price index in which selling price is a Cobb-Douglas function of a number of property characteristics with land area being just one of the characteristics. By shifting the other property characteristic variables, it is possible to obtain predictions of land value alone.

Introduction

There is some evidence that high voltage transmission lines and towers do not penalize proximate residential property in terms of selling price. Doubt is cast on the accuracy of this evidence because of the combination of two factors: (1) lot area is not held constant in these studies, and (2) developers tend to increase the area of lots that have an easement for a power line, while perceived lot area goes beyond the true lot line along a corridor right-of-way. Thus larger lot area, real or perceived, may compensate for proximity to the lines thereby disguising the penalty. What is needed for just compensation is knowledge of the impact on selling price while holding constant such things as lot area, real or perceived.

Literature

The issue of larger lots being associated with power lines thus offsetting detrimental effects was first mentioned by Kinnard [6] and later by Alleman [1]. A prime example of this kind of error is to be found in the survey results of Carll [3]. A more subtle error is found in the work of Bigras [2], and Derbes [5] (see also a recent working paper by Kinnard, Mitchell and Webb [7]). Derbes' sample includes lots that are almost exactly the same size and shape regardless of whether the lot is contiguous to the right-of-way or removed from

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the right-of-way. While it may seem that Derbes has controlled for lot size, he has not done so in an important sense. Similarly, Bigras compares average unit prices of contiguous parcels to those of other parcels, ignoring the effect of the rights-of-way. Those lots that are contiguous with the right-of-way are larger in the sense that they have substantive use of the greenbelt that is the right-of-way. The open view is certainly available to them, and as a matter of practice, contiguous property owners have been known to extend their use of the right-of-way to swing sets, gardens, and other explicit use. Suppose that the greenbelt had not included power lines. One might expect that proximate properties would receive a premium. If we find that there is no premium or discount, it is natural to imagine that there are offsetting effects.

This paper avoids the Derbes/Bigras problem by using a sample of properties proximate to a power line located on easements rather than a fee right-of-way. In so doing, this paper raises new questions and provides results concerning whether the value decrement is simply associated with the easement and not with proximity to the line, ceteris paribus.

This paper is also differentiated from the previous literature in that it tests the hypothesis that the impacts of power lines diminish through time. Both Kinnard [6] and Reese [8] introduce the idea that the impact would be diminished if power lines and/or towers are screened from view. Kinnard also offers the opinion that the impact diminishes through time. While it is tempting to hypothesize that diminution of the effect is caused by the growth of trees that screen the lines and towers, there are a number of other reasonable hypotheses that are consistent with such a trend.

The Hypotheses and the Model

The first hypothesis is that residential selling prices are related to both proximity to the lines and proximity to the towers. Of course, the form that these relationships take is very important for measurement and for policy purposes. So, more specifically, it is very likely that lines and towers have a large negative impact in close proximity but that any impact declines at a decreasing rate as distance increases. Additional distance beyond a few hundred feet might make very little difference.

The second hypothesis is that any impact of the power lines and towers might be lessened through time. The following model was developed to represent these hypotheses:

$$SP_i = \beta_0 \prod_{j=1}^{5} x_{ij}^{\beta_j} \exp\Big[\sum_{j=6}^{7} \beta_j x_{ij} + \beta_8(MOS_i) + \beta_9(1/DLN_i) + \beta_{10}(MOS_i/DLN_i) + \beta_{11}(1/DTWR_i) + \beta_{12}(MOS_i/DTWR_i)\Big] \tag{1}$$

where

SP_i = the selling price of the i^{th} property,
x_{ij} = the j^{th} characteristic of the i^{th} property or sale,
DLN_i = the distance in feet from the center of the i^{th} property to the transmission line (i.e., the center of the easement),
MOS_i = the month of sale of the i^{th} property, and
$DTWR_i$ = the distance in feet from the center of the i^{th} property to the nearest tower.

According to the first hypothesis,

$$\beta_9, \beta_{11} < 0.$$

The second hypothesis suggests that

$$\beta_{10}, \beta_{12} > 0.$$

Also, the relative magnitudes of β_9 and β_{10} and of β_{11} and β_{12} should be such that the direction of the impact of lines or of towers is not reversed within the relevant range of *MOS*. That is,

$$\beta_9 + \beta_{10}(\max MOS) \leq 0, \text{ and}$$

$$\beta_{11} + \beta_{12}(\max MOS) \leq 0.$$

The Data and the Variables

The data are those that were used in Colwell and Foley [4] with the addition of variables for distance to a tower and the presence of an easement. Data were obtained from several sources. Large-scale plat maps furnished by the surveyors facilitated the accurate determination of lot areas and distance to the transmission line and towers. Data on property characteristics were obtained from property appraisal cards in the office of the supervisor of assessments.

Revenue stamps on each deed, verified by the transfer declaration, provided the selling price data. The transfer declaration discloses the full amount of consideration, the date and type of deed, certain characteristics of the property, and whether the transfer is between relatives or is a compulsory transaction. Since January 1, 1968, it has been necessary in Illinois for both parties to the transaction or their agents to attest to the accuracy of the transfer declaration by signing it. Willful falsification of the selling price on the transfer declaration constitutes a class B misdemeanor. Thus, it is felt that the price data are relatively accurate.

All properties in the sample are within 400 feet of the center of the electric transmission line in two subdivisions, Holiday Hills and Windsor Village, of Decatur, Illinois [4]. The sample consists of 200 sales from these study areas. The sample period is nearly eleven years, extending from January 1, 1968 to October 31, 1978. The beginning of the sample period is the day on which the Real Estate Transfer Act became effective.

Six variables describe the characteristics of the site and improvements. These are lot size, building size, number of bathrooms, basement, garage size, and the presence of a deck. *LTSF* is the area of the lot in square feet. Because of the tendency for lot areas adjacent to an electric transmission line to be larger, the only way to distinguish the partial effect of proximity of residential property to the line on selling price is to include a lot-area variable.

LVSF+1 refers to the living area of the house in thousands of square feet plus 1. *BATH*+1 represents the number of bathrooms plus 1. The basement variable, *BSMT*+1, is a linear transformation of a more conventional basement variable that takes on values of

0, 0.5, and 1. The conventional variable is multiplied by 2 before adding 1. So this variable equals 1 for a property with no basement; 2 for a property with a half basement; and 3 for a property with a full basement. *GRSF*+ 1 is the area of the garage in thousands of square feet plus 1.

The estimated elasticity coefficients for these five variables, *LTSF, LVSF*+ 1, *BATH*+ 1, *BSMT*+ 1, and *GRSF*+ 1, are expected to fall between 0 and 1, indicating diminishing marginal contributions from each of these five variables. The sum of the estimated coefficients on these five variables should be close to 1, indicating constant returns to scale in these variables. If so, doubling all these five variables results in doubling the selling price, other things remaining equal (i.e., two identical residential properties would be worth twice as much as one).

The four improvement variables (*LVSF*+ 1, *BATH*+ 1, *BSMT*+ 1, and *GRSF*+ 1), each have 1 added so that the property need not have some particular improvement such as a garage or a basement in order to have a positive selling price. Although this has practical consequences, because garages and basements do not exist throughout the sample, it may be viewed as just a conceptual nicety for the living area and bathroom variables. However, as a practical matter, it should be possible to predict vacant lot price using this model as a result of having shifted the improvement variables by adding 1 to each.

There are two dummy variables, *DECK* and *NBRHD*. *DECK* indicates whether or not the house sold has a deck or porch and *NBRHD* indicates whether the property is in Holiday Hills or Windsor Village. *NBRHD*= 1 for Holiday Hills. The antilog of the coefficient on a dummy variable such as a *DECK* or *NBRHD* is the ratio of the selling price of a house with the feature to that without.

All the seven variables described above were included in Model 1 so that the partial effects of the towers, transmission lines, and the impact of time on these effects may be detected. The variables 1/*DLN* and 1/*DTWR* measure proximity (i.e., the reciprocal of distance) of residential property to the electric transmission line and to the tower, respectively. Thus, as distance to the line or tower increases, the proximity variables decrease. If the coefficient on the proximity variable is negative, selling price rises and

Exhibit 1
Summary Statistics of Data

Variable	Maximum	Minimum	Std. Dev.	Mean
SP	53.9	15	8.191	27.977
LVSF	2.852	0.816	0.399	1.416
BATH	3.5	1	0.38	1.357
BSMT	3	0	0.831	0.835
GRSF	0.576	0	0.146	0.32
LTSF	30.75	5.416	4.201	9.863
DECK	1	0	0.434	0.25
NBRHD	1	0	0.385	0.18
MOS	128	0.733	35.612	59.744
DLN	400	10	122.028	199.624
DTWR	1443	60	181.779	307.288
ESMT	1	0	0.484	0.37

approaches an asymptote as distance increases. The function is, however, not remarkably well-behaved as distance gets very small.

The variables $MOS(1/DLN)$ and $MOS(1/DTWR)$ are constructed to detect the impact of time on the effects of the two proximity variables (DLN, $DTWR$) described above. The speculation is that any effects that do exist might be diminished through time. This diminution may be attributed to the growth of trees obscuring view of lines and towers, changing attitudes about lines and towers, or a reduction in the uncertainty of the effects of lines and towers.

Summary statistics for the raw data are provided in Exhibit 1. Note that SP is in thousands of dollars, $LVSF$, $GRSF$ and $LTSF$ are in thousands of square feet, and DLN and $DTWR$ are in feet. All other variables are self-explanatory or explained above.

Estimation and Results

In order to make the model susceptible to linear estimation methods, equation (1) was transformed into natural logarithms as follows:

$$\begin{aligned} \ln SP_i = {} & \beta_0 + \beta_1(\ln LVSF+1) + \beta_2(\ln BATH+1) + \beta_3(\ln BSMT+1) \\ & + \beta_4(\ln GRSF+1) + \beta_5(\ln LTSF) + \beta_6(DECK) + \beta_7(NBRHD) \\ & + \beta_8(MOS) + \beta_9(1/DLN_i) + \beta_{10}(MOS_i/DLN_i) + \beta_{11}(1/DTWR_i) \\ & + \beta_{12}(MOS_i/DTWR_i) \end{aligned} \tag{2}$$

Two versions of the transformed model were estimated using Ordinary Least Squares with the results shown in Exhibit 2 (see Models 1 and 2). While Model 1 provides estimates for all the parameters in equation (2), Model 2 omits the last two variables, the ones relating to towers.

The explanatory power of these models is quite high. The adjusted coefficient of determination for Models 1 and 2 are both 0.771. Unadjusted, about 78.5% of the variation in the log of selling price is explained by these models. Every coefficient has the expected sign in both models.

All but four of the coefficients in Model 1 differ significantly from zero at the 90% level of confidence. The exceptions are the coefficients on $DECK$, $1/DTWR$, MOS/DLN, and $MOS/DTWR$. The first two of these are only significant using a one-tail test at the 90% level of confidence. A case could be made for a one-tail test being the appropriate test. The $MOS/DTWR$ is insignificant at any reasonable level of confidence. All but one of the coefficients in Model 2 differ significantly from zero at the 90% level of confidence. The exception is the coefficient on $DECK$. Model 2 differs from Model 1 in that it excludes the variables $1/DTWR$, and $MOS/DTWR$.

As distance to the line approaches infinity, the rate of appreciation becomes simply β_8 in this model. Thus, the product of this coefficient when multiplied by 12 yields an annual rate of appreciation during the sample period for properties not impacted by the power line.

Exhibit 2
Regression Results

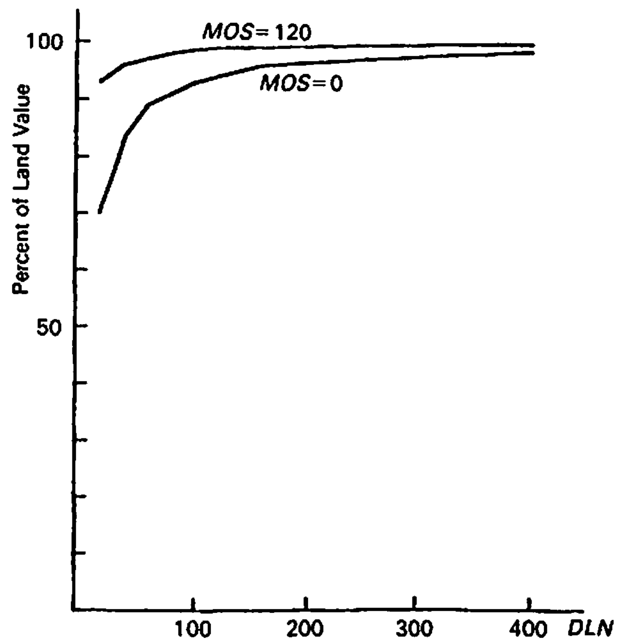
Explanatory Variable	Model 1 Coefficient (Std. Error)	Model 2 Coefficient (Std. Error)	Model 3 Coefficient (Std. Error)
Constant	2.111*** (0.1297)	2.0995*** (0.1294)	1.9974*** (0.1271)
$ln(LVSF+1)$	0.4004** (0.0847)	0.3932*** (0.0846)	0.3774*** (0.0842)
$ln(BATH+1)$	0.2289** (0.0918)	0.2459* (0.0903)	0.3182** (0.0964)
$ln(BSMT+1)$	0.1214*** (0.0256)	0.1195*** (0.0254)	0.1332*** (0.0257)
$ln(GRSF+1)$	0.2804** (0.0896)	0.2753** (0.0896)	0.3271** (0.0908)
$ln(LTSF)$	0.0850** (0.0409)	0.0731* (0.0396)	0.0801** (0.0389)
$DECK$	0.0342† (0.0248)	0.0310† (0.0240)	0.0106 (0.0258)
$NBRHD$	0.0798** (0.0303)	0.0839** (0.0301)	0.0506* (0.0312)
MOS	0.0057*** (0.0005)	0.0060*** (0.0004)	0.0065*** (0.0003)
$1/DLN_i$	−6.2276** (2.0309)	−6.9344*** (1.9723)	—
MOS/DLN_i	0.0383† (0.0234)	0.0464** (0.0227)	—
$1/DTWR$	−8.7575† (6.0382)	—	—
$MOS/DTWR$	0.0951 (0.0802)	—	—
$ESMT$	—	—	−0.0559** (0.0255)
$(1-ESMT/DLN_i)$	—	—	−5.1409*** (1.2914)
R^2	0.771	0.771	0.772

***significant at the 99% level of confidence
**significant at the 95% level of confidence
*significant at the 90% level of confidence
†significant at the 90% level of confidence (one-tail)

The estimated annual rates for the two models are 6.8% and 7.2%, respectively. These rates are very realistic for the period and location.

The proximity variable $1/DLN_i$ is used in Models 1 and 2 as shown in Exhibit 2. The coefficient on this variable is significantly negative in both models. This means that selling price becomes higher as distance from the wires increases. The specific form of the function suggests that, over the relevant range, selling price increases at a decreasing rate and quickly approaches an asymptote. This intuitively appealing relationship is illustrated in Exhibit 3 based on Model 2 and on $MOS=0$.

Exhibit 3
Land Value as a Function of Distance to a Transmission Line



The proximity variable $1/DTWR$ worked less well than the corresponding power line variable in Model 1. As shown in Model 1, the coefficient on this variable is not significantly different from zero at the 90% level of confidence. Thus, this variable is excluded from Model 2.

The coefficients on the variable $MOS(1/DLN_i)$ are significantly positive in both Models 1 and 2. This means that the impact of the proximity variable $(1/DLN_i)$ diminished through time. The impact of time is illustrated in Exhibit 3 utilizing the parameters in Model 2 and $MOS=120$. The value impact of distance to the power line disappears after 13.5 years according to Model 1 and 12.4 years according to Model 2. These periods date from the time of the first observations in this study and not from the time of the announcement or installation of the power lines. The $MOS/DTWR_i$ variable was included in Model 1. However, this variable proved to be insignificant, thus it is excluded from Model 2.

In both models, the coefficient on the neighborhood variable indicates that a Holiday Hills location is more expensive than a Windsor Village location. The premium is approximately 8.3% and 8.8%, for Models 1 and 2, respectively.

The coefficient on the variable *DECK* is significantly positive in both Models 1 and 2. The premium due to deck is approximately 3.5% and 3.1% for Models 1 and 2, respectively. Decks and porches are generally small in these neighborhoods, thus it is no wonder that their impact on selling price is small.

The coefficients on the five property characteristic variables ($\ln LTSF$, $\ln LVSF+1$, $\ln BATH+1$, $\ln BSMT+1$, $\ln GRSF+1$) are each significantly between 0 and 1, in both

Exhibit 4
Correlation Coefficients

	ln *LVSF*+1	ln *BATH*+1	ln *BSMT*+1	ln *GRSF*+1	ln *LTSF*	*DECK*	*NBRHD*	*MOS*	I/*DLN*$_i$	*MOS/DLN*$_i$	I/*DTWR*	*ESMT*
ln *BATH*+1	0.64											
ln *BSMT*+1	0.30	0.37										
ln *GRSF*+1	0.08	0.17	0.16									
ln *LTSF*	−0.16	−0.20	−0.17	0.13								
DECK	0.23	0.15	−0.03	0.21	0.01							
NBRHD	0.03	0.02	0.34	0.14	0.32	0.15						
MOS	−0.01	−0.05	−0.08	−0.03	0.02	−0.06	−0.06					
I/*DLN*$_i$	0.33	0.27	0.14	0.04	0.46	0.13	0.11	0.08				
MOS/DLN$_i$	0.25	0.26	0.13	0.08	0.35	0.05	0.05	0.39	0.85			
I/*DTWR*	0.02	−0.11	0.03	0.06	0.23	0.21	0.01	0.03	0.26	0.19		
MOS/DTWR	0.06	−0.09	0.01	0.02	0.14	0.12	−0.04	0.58	0.23	0.39	0.72	
ESMT	0.13	−0.12	0.01	−0.14	0.30	0.30	0.07	0.06	n.a.	n.a.	n.a.	
(I-*ESMT*)/*DLN*$_i$	0.26	0.44	0.18	0.16	0.18	−0.11	−0.07	0.05	n.a.	n.a.	n.a.	−0.26

models, indicating diminishing marginal contributions from lot size, living area, bathrooms, basement and garage. The sum of these coefficients is close to unity indicating approximately constant returns to scale in these five variables. These variables, of course, are highly related to excluded variables but, in general, are not themselves highly interrelated, as shown in the matrix of correlation in Exhibit 4. The exception is the relationship between living area and baths.

Eliminating Easement Impact

There may be the suspicion that the proximity variables in Models 1 and 2 work only because properties with easements are included in the sample and the impact of the line extends only to those properties. This suspicion implies that all the value effects of the transmission line derive from the presence of an easement and its concomitant restriction of rights. The following transformed model including easement variables was developed in order to separate the value effects due to an easement from those purely related to proximity.

$$\begin{aligned} \ln SP_t = {} & \alpha_0 + \alpha_1(\ln LVSF+1) + \alpha_2(\ln BATH+1) + \alpha_3(\ln BSMT+1) \\ & + \alpha_4(\ln GRSF+1) + \alpha_5(\ln LTSF) + \alpha_6(DECK) + \alpha_7(NBRHD) \\ & + \alpha_8(MOS) + \alpha_9(ESMT) + \alpha_{10}(\{1-ESMT\}/DLN_i) \end{aligned} \tag{3}$$

where

$ESMT$ = a dummy variable with $ESMT=1$ for properties having an easement and $ESMT=0$ if they did not have an easement.

Model 3 above was estimated using Ordinary Least Squares and the results are shown in Exhibit 2. All the coefficents in Model 3 differ significantly from zero at the 90% level of confidence, except the coefficient on *DECK* which is insignificant. The adjusted coefficient of determination for Model 3 is 0.772.

The dummy variable for easement (*ESMT*) is significantly negative in Model 3 meaning that easements have negative impacts on property values. More importantly, the coefficient on the $[(1\text{-}ESMT)/DLN]$ variable is significantly negative meaning that value increases away from transmission lines on lots without easements. Thus, it is not just the easement but it is also purely proximity that has an impact on value.

Otherwise Model 3 is similar to the other models. The annual rate of appreciation for Model 3 is 7.8%. Like Models 1 and 2, the coefficient on the neighborhood variable indicates that a Holiday Hills location is more expensive than a Windsor Village location. The premium in Model 3 is 5.2%. The coefficient on *DECK*, however, is insignificant in Model 3.

All the coefficients on the five property characteristic variables ($\ln LTSF$, $\ln LVSF+1$, $\ln BATH+1$, $\ln BSMT+1$, $\ln GRSF+1$) worked as expected for Model 3 also. Each of the coefficients is significantly between 0 and 1, indicating diminishing marginal contributions from lot size, living area, bathrooms, basement and garage. Again, the sum of these coefficients is close to unity indicating approximately constant returns to scale in these five variables.

Multicollinearity

Exhibit 4 gives the correlation coefficients for the correlations between all pairs of the explanatory variables that appear in the same equation. As far as the physical characteristics of the properties themselves, it appears that the only substantial collinearity is between the living area and bathroom variables. Yet the relative and absolute sizes of the coefficients on these variables are within the anticipated ranges, so there may be no problem here.

As is generally the case when developers plat a subdivision after a transmission line is in place, lot size is correlated with proximity to the line. Developers appear to compensate those located along the line with larger lot sizes. The existence of this relationship is the reason for the inclusion of a lot size variable. To omit the lot size variable would tend to lower the estimate of the impact of the transmission line.

The month of sale is highly correlated with the two variables in which it is found as the numerator (i.e., MOS/DLN_i and $MOS/DTWR$). The impact of this can be seen on the difference in the estimated coefficients on MOS in the two models. Model 2 which excludes the $MOS/DTWR$ variable has a higher coefficient on MOS. This suggests that it is not just the passage of time or general appreciation that is causing these properties to increase in value. Something is contributing to the appreciation close to the line.

Summary and Conclusions

The hypothesized relationships between the proximity variables ($1/DLN_i$, MOS_i/DLN_i) and land value are demonstrated for the sample in this study. Models 1 and 2 clearly establish that proximity to a power line is associated with diminished selling prices. Both models, however, show that this impact (i.e., reduced selling prices with greater proximity) is diminished through time perhaps as the growth of trees obscures the view of the electric transmission lines or perhaps for other reasons. As shown in Exhibit 2, the tower variable $1/DTWR$, however, did not work exceptionally well, although a case can be made that the negative impact of proximity to towers is significant. The variable $MOS/DTWR$ proved insignificant suggesting that the impact of towers does not diminish with time.

Model 3 establishes that easements have negative impacts on the values of property in the sample. The result for the variable $(1\text{-}ESMT)/DLN$ establishes that value increases away from transmission lines on lots without the easement. Therefore, this study establishes that there are value effects due to the easement as well as those that relate purely to the proximity of power lines.

In sum, this study establishes that the negative impact of power lines is large in close proximity but declines as distance increases. Furthermore, the impact of the lines diminishes with time. Additionally, there may be a negative value impact of proximity to towers, but this impact showed no significant signs of diminishing through time. Finally, this paper demonstrates that the impact of transmission lines is not just related to the easement. Rather, there is a proximity effect even for those properties that do not have the easement.

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Hsiang-te Kung, PhD, and Charles F. Seagle

Impact of Power Transmission Lines on Property Values: A Case Study

Studies have been conducted in an attempt to link electromagnetic radiation to some forms of cancer and other health risks. Each study has produced differing levels of evidence as to the validity of this theory. This research project endeavors to analyze the impact of power transmission lines on residential property values and the marketability of real estate in Memphis and Shelby County, Tennessee. Public knowledge of a possible connection between electromagnetic radiation and health risks such as cancer would probably have a profound effect on the real estate market for homes located in close proximity to power transmission lines.

The purchase of a home is often the biggest single investment a person will ever make. This is not an investment that is taken lightly, and any homeowner wants to protect the value and future benefits of ownership.[1] Regular maintenance, landscaping, and home additions can protect and enhance the value of property. External factors, however, such as the presence of adverse conditions or features adjacent to property that are beyond a homeowner's control can and do affect property values.[2] Examples of adverse external factors are dumps, landfills, factories that produce noise and bad odors, neighbors who allow their property to deteriorate, and of course power transmission lines.

There are two ways in which power transmission lines may adversely affect property value or marketability. The first is the mere presence of the transmission towers, which create an eyesore, as well as easements and encroachments on properties. The second, somewhat latent, is not as widely known. Since the late 1970s, studies have been conducted to attempt

1. American Inst. of Real Estate Appraisers, *The Appraisal of Real Estate*, 9th ed. (Chicago: American Inst. of Real Estate Appraisers, 1987), 35–41.
2. Ibid.

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to determine whether there is any connection between electromagnetic radiation emitted by power transmission lines and possible health hazards such as cancer.[3] The presence of these possible health hazards, if known to the general public, could certainly lead to a decrease in demand for properties located near transmission lines and in turn lower property values in these areas.

LITERATURE REVIEW

The cornerstone study of electromagnetic fields (EMFs) and their connection with health hazards was conducted in the 1970s by Nancy Wertheimer and Ed Leeper in Denver, Colorado.[4] In their study, Wertheimer and Leeper compared the EMF exposure of 344 children who died of cancer over a 23-year period from 1950 to 1973 with those of an equal number of children who did not get cancer born at approximately the same time as the cancer victims. Wertheimer and Leeper concluded that the children who lived in high-exposure homes (i.e., homes in close proximity to the power transmission lines) were two to three times more likely to contract some form of cancer, particularly leukemia, lymphomas, and nervous system tumors, than were the children who lived in lower exposure homes (i.e., homes not in close proximity to power transmission lines).

The results of this study were greeted with both skepticism and heightened interest in the research community. Skeptics agreed that too many assumptions were made as to the intensities of EMFs, and that actual measurements were not made. Nonetheless, the results led to more studies that used better control measures.

One such study was conducted in the Denver metropolitan area by David A. Savitz.[5] Savitz's goal was to replicate the study of Wertheimer and Leeper using more controlled measures and a greater level of thoroughness. It was generally thought that this study would disprove the results of Wertheimer and Leeper. It merely improved and refined them, however, giving greater weight to the evidence that there may be some connection between exposure to EMFs and some forms of cancer.[6]

Other studies were expanded to include electromagnetic radiation emitted from household appliances such as hairdryers and electric blankets.[7] Still another study, conducted in England, produced evidence that persons living or working near electromagnetic fields are subject to more depression and a greater incidence of suicide.[8]

Research conducted by Kavet and Banks indicated that EMFs do have some effects on cell membranes and tissues.[9] The biological responses *in vitro* are sensitive, not only to the magnitude of the radiation, but

3. Robert Pool, "Is There an EMF-Cancer Connection?" *Science*, v. 249 (September 1990): 1096–1098.
4. Ibid.
5. David A. Savitz and Debra L. Zuckerman, "Childhood Cancer in the Denver Metropolitan Area 1976–1983," *Cancer*, v. 59 (1987): 1539–1542.
6. Pool, 1096–1098.
7. David A. Savitz, Esther M. John, and Robert C. Kleckner, "Magnetic Field Exposure from Electric Appliances and Childhood Cancer," *American Journal of Epidemiology*, v. 131, no. 5 (1990): 763–773.
8. Stephen F. Perry, "Environmental Power-Frequency Magnetic Fields and Suicide," *Health Physics*, v. 41 (August 1981): 267–277.
9. Robert I. Kavet and Robert S. Banks, "Emerging Issues in Extremely Low-Frequency Electric and Magnetic Field Health Research," *Environmental Research*, v. 39 (1986): 386–404.

also to the waveshape and frequency of the radiation. On the other hand, studies on animals and humans are inconclusive. They fail to produce results comparable with the cell results and attest to the need for more research.[10]

In general, while all of the previously noted studies manifest varying levels of health hazards in relation to electromagnetic fields (as a result of differences in control groups and measures as well as techniques), they all suggest that there is some evidence to support a link between electromagnetic fields and health problems such as cancer.

METHODS AND PROCEDURES

The study discussed in this article was an attempt to analyze the spatial relationships between power transmission lines and property values in Memphis and Shelby County, Tennessee. Using power line maps available from Memphis Light, Gas, and Water (MLGW), neighborhoods transected by high tension lines were identified. Once these areas had been identified, individual homes directly under or adjacent to these power lines were surveyed to collect data on real or perceived influences on the property's value or marketability. This survey addressed both the issue of possible health hazards and the negative aesthetic impact of power lines.

Information was gathered concerning any differences between prices paid for homes directly under or adjacent to power transmission lines, and prices paid for homes in the same neighborhoods but located further away from the power transmission lines. The data were gathered from recognized local real estate services (e.g., Chandler and Chandler Residential Report, Memphis Association of Realtors Multiple Listing System), and used comparable types of housing as they could be located.

All data obtained through surveys, research, and personal observations were used to formulate a computerized map to show the spatial distribution of residential houses adjacent to transmission power lines as well as a computerized database (i.e., attribute data file) for the residential real estate property, called a Geographic Information System (GIS). Included in the database for the GIS are locations, distance to transmission power lines, square footage, type of housing, and information listed in the current Multiple Listing System (MLS) near the power lines. The database established by using the GIS can easily be updated.

In addition to the database construction of residential real estate value affected by power lines, a questionnaire was developed to survey homeowners who lived in houses directly adjacent to the power transmission lines. The responses to the following questions were used to determine the amount of influence the presence of power lines has on value.

1. When you purchased your home, did you consider the close proximity of the power lines and towers as a negative influence either as an eyesore (aesthetic negative) or as a potential health hazard?
2. If so, did either factor influence the price you were willing to pay for your home?
3. There is some evidence that these types of power lines and the electromagnetic radiation

While all of the previously noted studies manifest varying levels of health hazards in relation to electromagnetic fields, they all suggest that there is some evidence to support a link between electromagnetic fields and health problems such as cancer.

10. Maria A. Stuchly, "Human Exposure to Static and Time-Varying Magnetic Fields," *Health Physics*, v. 51, no. 2 (1986): 215–225.

they emitted may cause some forms of cancer. Were you aware of this when you purchased your home?

4. If you had been aware of such evidence (i.e., the possibility of a link between the electromagnetic field emissions from power lines and some cancers) would it have adversely affected the price you would have been willing to pay for your home? or

   Would this information have caused you to look elsewhere for comparable housing distant from power transmission lines?

5. Do you think that if this information about the possible link between power lines and their electromagnetic fields to cancers was more widely publicized that the market for homes located near such power lines likely would decline?

The results of this questionnaire were compiled, analyzed, and reconciled along with market information into a summary and conclusion.[11]

DISCUSSION

The results of the survey provide the basic information in this discussion. Of 80 homeowners in 2 adjacent neighborhoods in east Memphis and Shelby County who were polled, 47 complete responses were received and analyzed. In response to question 1, 25 homeowners (53%) said that they consider the presence of the transmission lines and towers an eyesore, while 22 (47%) did not. In response to the second half of the question, no homeowners considered the presence of the transmission lines and towers as a possible health hazard. In other words, every single homeowner who responded said they did not consider the transmission lines or towers a health hazard.

Of the 25 affirmative responses to question 2, 7 homeowners (28%) said that the presence of transmission lines and towers affected the price they were willing to pay for their homes. The presence of transmission lines and towers did not affect the price 18 homeowners (72%) were willing to pay, however.

Some interesting and enlightening responses were received to questions 3 and 4. Of the 47 homeowners surveyed, none had any knowledge of the possible evidence connecting power transmission lines to certain health risks such as cancer. This led to question 4 and some predictable responses. If these homeowners had been aware of the potential health risks associated with the presence of the electromagnetic fields emitted by transmission lines, 41 (87%) said that the price they had been willing to pay for their home would have been adversely affected or they would have looked in other areas for comparable housing. For two respondents (4%), access to such information might have had an influence on the price paid for their home or where they were willing to buy a home. Only one respondent would not have changed either the price paid for the home or the location of the home as a consequence of such information.

The last question posed in the survey was an opinion question. In light of the information concerning the connection between the electromagnetic fields of power trans-

11. K. William Chandler, *Chandler and Chandler Residential Sales Report, Memphis and Shelby County Homes, Duplexes, Condominiums, and Lots* (1989 and 1990).

mission lines to possible health risks such as cancer, what did the homeowners think would happen to the market for homes located in close proximity to power transmission lines if this information were widely publicized and known to the general public? Forty-three respondents (91%) said that they thought the market for these homes would decline, while one said that it would have no effect on the market for these homes.

An attempt was also made to gather information concerning any difference in prices paid for homes directly adjacent to power transmission lines and prices paid for homes in the same neighborhoods but further from the power transmission lines. Information was extracted from the subject neighborhoods using up-to-date sources (1989–1990 Chandler & Chandler residential reports), and using comparable housing as located.

In neighborhood A, two subject properties (i.e., properties adjacent to the power transmission lines) sold for $54,759 ($46.28 per square foot) and $55,350 ($49.64 per square foot), respectively. These prices fall in line with three comparable properties (i.e., properties of approximately the same age, size, and quality, located in the same neighborhood but not directly adjacent to the power transmission lines). These three properties sold for $56,900 ($44.66 per square foot), $55,500 ($51.48 per square foot), and $53,500 ($48.28 per square foot), respectively. The average price of the subject homes, $55,054 ($47.96 per square foot) compares favorably with the comparable homes, with an average price of $55,300 ($48.14 per square foot).

In neighborhood B, two subject properties sold for $67,000 ($54.96 per square foot) and $65,000 ($53.32 per square foot), respectively. These prices are in line with four comparable properties, which sold for $68,500 ($53.64 per square foot), $66,685 ($56.51 per square foot), $67,500 ($55.19 per square foot), and $65,500 ($51.65 per square foot), respectively. The average price of the subject homes was $66,000 ($54.14 per square foot) and again compares favorably with the comparable homes average of $67,046 ($54.25 per square foot).

Any slight difference in total price or price per square foot between the subject homes and the comparable homes should be attributed to differences in property condition, style, or buyer preference and seller motivation. This is supported by a comparison of select groups of only comparable properties and the resultant similar slight price differences. These differences are common in any real estate market.

CONCLUSION

Although there is evidence that the electromagnetic fields emitted from power transmission lines may cause some forms of cancer and that the presence of power lines and towers are an eyesore, these results reveal that the public in general is only aware of the latter. While survey results indicate little knowledge of potential health risks, they indicate a high degree of opinion change once informed about such evidence.

Market evidence further supports the fact that there is a lack of public knowledge about any health risks associated with power transmission lines because no measurable price differences could be detected between homes located adjacent to power transmission lines and comparable homes located further away.

More research needs to be conducted in the area of electromagnetic fields and their connection to health risks. The results must be more widely disseminated to the general public. Further, development in the future clearly should be restricted in the vicinity of power lines and should be kept a significant distance from power transmission lines and towers.[12]

12. Hsiang-te Kung and Paul M. Barelski, "Environmental Effects of Electromagnetic Radiation from Power Lines," unpublished paper, 1990.